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DAMPING CONTROL OF DISTRIBUTED POWER FLOW CONTROLLER FOR IMPROVING THE TRANSIENT STABILITY USING FUZZY LOGIC CONTROLLER

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ABSTRACT

The basic knowledge of the FACTS devices, which will be applied in this paper, is the most encouraging one, which is known as the Distributed Power Flow Controller (DPFC). Because of the control ability of various types of Power flow controlling devices, the pattern is that mechanical PFCDs are progressively being supplanted by Power Electronics (PE) Devices. The main theme of this paper is to build up another PFCD that offers a similar control ability as the UPFC, at a low cost and with an expanded reliability quality. The new device, namely Distributed Power Flow Controller (DPFC), is proposed in this paper and the performance of the NFIS explored here in the Fuzzy control of a DPFC. NFIS is utilized as a part of specific learning calculation as a controller. This paper determines the criteria to introduce the DPFC in perfect area with optimal parameters and after that outlines of an AI based damping controller for improving power flow system with dynamic execution. The proposed supplementary control in view of the fuzzy rationale will be varied in damping power signals.

KEYWORDS: FACTS Devices, Power Flow Controlling Devices (PFCD$_S$), Distributed Power Flow Controller (DPFC), Fuzzy Logic, NFIS, Perfect Location, Damping Controller

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INTRODUCTION

In the most recent years, the electrical power quality issue has been the principle concern of the power generation organizations [1]. Control quality is described as the list which both the delivery and utilization of electric power impact on the implementation of electrical device [2]. From a consumer perspective, a power quality issue can be characterized as any issue is showed on voltage, current, or frequency deviation that outcomes in power failure [3]. The power electronic equipment, particularly in adaptable Flexible A.C transmission system (FACTS) and custom power devices, influences control quality change [4], [5]. In general, custom power devices, e.g., dynamic voltage restorer (DVR), is utilized as a part of medium-to-low voltage levels to enhance consumer control quality [6]. Most genuine dangers for sensitive hardware in electrical grids are voltage sags (voltage plunge) and swells (over voltage). These unsettling influences happen because of a few cases, e.g., cut off the matrix, inrush streams required with the beginning of enormous machines, or exchanging operations in the grid. The FACTS devices, for example, brought together power flow controller (UPFC) and synchronous static compensator (STATCOM), are utilized to reduce the disturbing power and enhance the power system quality and steady quality [7], [8]. Quick power stream controlling devices in power electronic devices (FACTS) are acquainted yet due with high costs are not generally utilized. Similarly, in view of the steady state quality and the

cost issues, the UPFC is not generally connected in current transmission line. The Distributed Power Flow Controller (DPFC) is another device of D-FACTS family. The DPFC gives higher steady state quality than ordinary UPFC at lower cost. In the UPFC to accomplish the required steady state quality, the bypass circuits and excess reinforcements are required which this builds the cost. In the DPFC to overcome these issues, various low rate series converters are utilized rather than one huge series converter. In this way, the cost of DPFC will be very less than the UPFC which increases its reliability. The DPFC distributes with the basic dc line between the shunt and series converters. The dynamic power trades between the shunt and the series converter through the transmission line at the third harmonic frequency.

Basically the Inverter is a device that believers DC source to AC source at desired output voltage and frequency. Undesirable marks of inverter are less ability, high cost, and high exchanging hardships. To overcome these faults, this paper described about the multilevel inverter. But for complex systems, the direct control is troublesomely adjusted to the non-straight power system. The fuzzy control can overcome non-direct elements and does not require exact numerical mode. For nonlinear systems, similar to the DPFC, fuzzy based control has been demonstrated to function admirably. In this paper, a Fuzzy based multilevel distributed control stream controller is proposed and is utilized to enhance control quality.

One of the reasons for the high cost is that the ratings of FACTS devices are normally in 100 MVA, with the system voltage from 100 kV to 500 kV. The second concern is possible failures in the combined FACTS. Two issues are considered: the reliability of the device itself and its influence on power system security. The combined FACTS are a complex system, which contains a large number of active and passive components. Due to these two major drawbacks, the UPFC and IPFC are not widely applied in practice. Even when there is a large demand of power flow control within the network, the UPFC and IPFC are not currently the industry's first choice.

DPFC CONTROL

To control different converters, a Distributed power flow controller involves of three types of controllers: central control, shunt control and series control, as shown in Figure 2.

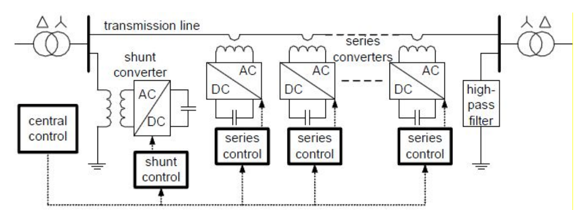

Figure 1: DPFC Control Block Diagram

The series and shunt control are confined controllers and are accountable for maintaining their own converters' parameters. The central control takes an attention of the Distributed power flow controller functions at the power system level.

The Role of Each Controller is Listed

- **Central Control**: Central control: this will control and produce the reference signals for both the shunt and series converters of the DPFC. Its control work relies upon the specifics of the DPFC application at the power system level, for example, control stream control, low repetition control wavering damping and adjusting of deviated parts. As indicated by the system necessities, the central control gives suitable voltage reference signals for the

series converters and reactive current signal for the shunt converter. All the reference signals produced by the central control concern the principal recurrence components.

- **Series Control**: Every series converters have its own series control. The controller is utilized to keep up the capacitor DC voltage of its own converter, by utilizing third harmonic frequency signals, although the producing arrangement of voltage at the crucial recurrence as required by the central control.
- **Shunt Control**: The theme of the shunt control is to shoot up a constant 3rd harmonic current into the line to supply active power for the series converters. In the meantime, it keeps up the capacitor DC voltage of the shunt converter at a consistent esteem by retaining the active power from the system at the central frequency and injecting the required responsive current at the key frequency into the grid.

Control of Third Harmonic Frequency Component

A 1-Phase converter is connected between the neutral of Y-Δ transformer and the ground is responsible for injecting constant 3rd harmonic current into the grid. Hence a Current controller is required to control this current. The 3rd harmonic current is locked at fundamental frequency along with bus voltage. The PLL is used to capture the bus voltage frequency and the output signal $\theta_{1,}$ multiplied with 3 in order to obtain 3rd harmonic component.

Current control loop design is the major loop in shunt converter 3rd harmonic control loop. The control loop is designed by comparing the relationship between 3rd harmonic current and shunt voltage. However the current control loop can be represented using two DC voltage sources resistor and inductor.

DPFC can control all the line parameters such as: line impedance, transmission angle, bus voltage and has same control capabilities of UPFC.

Usage of large no of series converters reduces cost and increases the reliability. Failure of any single phase converter does not affect the system operation. No phase to phase voltage isolation required between the series converters of different phases. And the power rating of each converter is low.

Damping Controller for Fuzzy Logic based DPFC

Input signs to the controller, power flow deviation from the consistent value ΔP and its essential ΔE, are gotten from the real power flow at the UPFC site. They must be driven back to zero for another consistent state by the damping controller [24], [25]. The way toward discovering ΔP and ΔE signals requires standard molding, including evacuation of the counterbalance segments and joining is appeared in Figure 4.

Figure 2: Attaining the Input Signals for Fuzzy Controller

The inputs are described by the following linguistic variables: P (positive), NZ (near zero), and N (negative). The output is described by five linguistic variables P (positive), PS (positive small), NZ (near zero), NS (negative small), and N (negative). Gaussian functions are used as membership functions for both inputs, and triangular membership functions are used for output (Figure 5). Damping signal is controller output. Fuzzy rules used are given in Table 1.

Table 1: Fuzzy Rules

if ΔE is NZ then damping signal is NZ
if ΔE is P then damping signal is P
if ΔE is N then damping signal is N
if ΔE is NZ and ΔP is P then damping signal is NS
if ΔE is NZ and ΔP is N then damping signal is PS

SIMULATION RESULTS AND DISCUSSIONS

Voltage reference DPFC Fuzzy Controller is shown in Figure 6**.** The main theme of structure of a DPFC Simulink model is shown in the Figure 7.

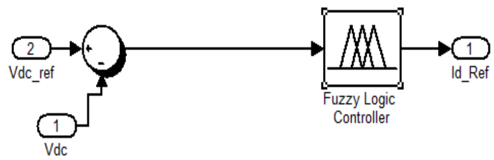

Figure 3: Voltage Reference DPFC Fuzzy Controller

In this division, the DPFC model is generated and simulated on Matlab/Simulink. All the results are based on the single-phase per-unit system. One shunt converter and two single phase series converters are built and simulated. The specifications of the DPFC in MATLAB are listed below table 2.

Table 2: Parameters of the DPFC

PARAMETERs	VALUE
Reference voltage(V_s)	200v
Receiving end Voltage(V_r)	200v
voltage at series converter	120v
voltage at shunt converter	120v
Resistance (r)	0.3864 Ω/km
inductance(L)	4.1264 mH/km
Source resistance (r_s)	0.8929 Ω
Source inductance(L_s)	16.58 mH
Series capacitor(C_{se})	1 μF
Shunt capacitor (C_{sh})	1 μF

The system under deliberation is simulated under various working conditions to examine its transient stability execution and to exhibit the adequacy of the proposed controller. The possibility under deliberation is a three phase fault at the sending end of one of the transmission lines when the generator is working at various power levels. The fault is considered to happen amongst t=0.2s and t=0.3s. The fault is cleared with the operation of transmission line reclosure.

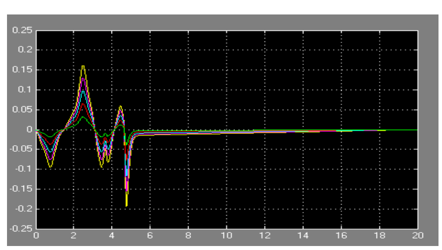

Figure 4: Speed Deviation Versus Time

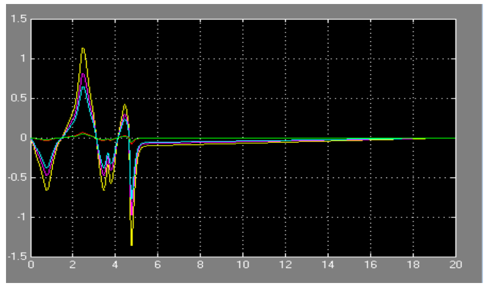

Figure 5: Power Angle Versus Time

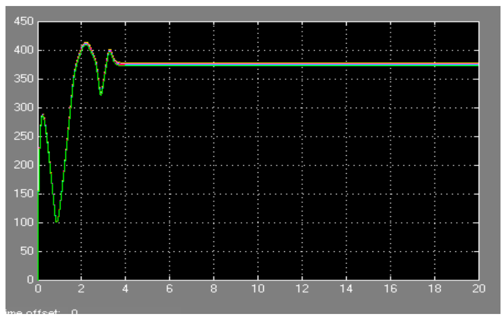

Figure 6: Real Power Versus Time

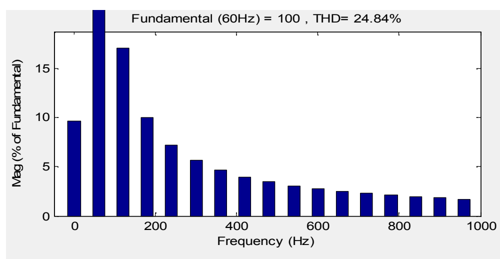

Figure 7: THD with Out Fuzzy

CONCLUSIONS

In this paper Fuzzy based Controller of a DPFC with multilevel voltage source converter (VSC) is presented here. The presented DPFC control system can direct line active and reactive power flow of the transmission line. The series converter of the DPFC utilizes the D-FACTS idea, which utilizes different converters rather than one huge size converter. The reliability quality of the DPFC is incredibly expanded in repetition of the series converters. The total cost of the DPFC is additionally much lower than the UPFC, on the grounds that no high-voltage confinement is required at the series converter part and the rating of the segments are low. Proposed simulation results are demonstrates that the change in Power Quality utilizing Fuzzy based DPFC. The proposed supplementary control in view of the fuzzy control is viable in damping power oscillations. The controller is decentralized since it requires just neighborhood estimation – the tie-line control power at the DPFC area. Reproduction comes and shown that the controller displays good damping qualities for various working conditions and compared with the ordinary controller indicates prevalent performance.

REFERENCES

1. *Anderson, P. M., Fouad, A.A., Power System Control and Stability, Iowa State University Press, 1977*
2. *Kundur, P., Power System stability and Control, McGraw-Hill Inc., 1994*
3. *Higorani, N.G, Gyugyi,L., Understanding FACTS Devices, IEEE Press 2000*
4. *Hingorani, N.G., 'Flexible AC Transmission', IEEE Spectrum, April 1993, p. 40-44*
5. *Gyugyi, L., 'Dynamic Compensation of AC Transmission Lines by Solid-state Synchronous Voltage Sources', IEEE, 1993, p. 904-911*
6. *Edris, A. Mehraban, A.S., Rahman, M., Gyugyi, L., Arabi, S., Rietman, T., 'Cotnrolling the Flow of Real and Reactive Power', IEEE Computer Application in Power, January 1998, p. 20-25*
7. *Gyugyi, L., 'A Unified Power Flow Control Concept for Flexible AC Transmission Systems', IEE Proceedings-C, Vol. 139, No. 4, July 1992, p. 323-331*
8. *Gyugyi, L., Schauder, C.D., Williams, S.L., Rietman, T.R., Torgerson, D.R., Edris, A., 'The Unified Power Flow Controller: A New Approach to Power Transmission Control', IEEE Transactions on Power Delivery, Vol. 10, No. 2, April 1995, p. 1085-1093*
9. *Noroozian, M., Angquist, L., Ghandhari, M., Andersson, G., 'Use of UPFC for Optimal Power Flow Control, IEEE Transactions on Power Delivery, Vol. 12, No. 4, October 1997, p. 1629-1634*
10. *Nabavi-Niaki, A., Iravani, M.R., 'Steady-state and Dynamic Models of Unified Power Flow Controller (UPFC) for Power System Studies', IEEE Transactions of Power Systems, Vol. 11, No. 4, November 1996, p. 1937-1943*
11. *Fuerte-Esquivel, C.R., Acha, E., 'Unified Power Flow Controller: A Critical Comparision of Newton-Raphson UPFC algorithms in Power Flow Studies', IEE Proceedings Generation Transmission Distribution, Vol. 144, No. 5, September 1997, p. 437-444*
12. *Fuerte-Esquivel, C.R., Acha, E., 'Newton-Raphson Algorithm for reliable Solution of Large Power Networks with Embedded FACTS Devices', IEE Proceedings Generation Transmission Distribution, Vol. 143, No. 5, September 1996, p. 447- 454*
13. *Ambriz-Perez, H., Acha, E., Fuerte-Esquivel, C.R, De la Torre, A., 'Incorporation of a UPFC Model in an Optimal Power Flow Using Newton's Method', IEE Proceedings Generation Transmission Distribution, Vol. 145, No. 3, May 1998, p. 336-344*
14. *Schauder, C., Metha, H., 'Vector Analysis and Control of Advanced Static VAR Compensators', IEE Proceedings-C, Vol. 140, No. 4, July 1993, p. 299-306*
15. *Papic, I., Zunko, P., Povh, D., Weinhold, M., 'Basic Control of Unified Power Flow Controller',, IEEE Transactions of Power Systems, Vol. 12, No. 4, November 1997, p. 1734-1739*
16. *Smith, K.S., Ran, L., Penman, J., 'Dynamic Modeling of a Unified Power Flow Controller', IEE Proceedings Generation Transmission Distribution, Vol. 144, No. 1, January 1997, p. 7-12*
17. *Padiyar, K.R., Kulkarni, A.M., 'Control Design and Simulation of Unified Power Flow Controller', IEEE Transactions on Power Delivery, Vol. 13, No. 4, October 1997, p. 1348-1354*
18. *Wang, H.F., 'Damping Function of Unified Power Flow Controller', IEE Proceedings Generation Transmission Distribution, Vol. 146, No. 1, January 1999, p. 81-87*
19. *Wang, H.F., 'Applications of Modelling UPFC into Multi-machine Power Systems', IEE Proceedings Generation Transmission Distribution, Vol. 146, No. 3, May 1999, p. 306-312*

20. *Uzunovic, E., Canizares, C.A., Reeve, J., 'Fundamental Frequency Model of Unified Power Flow Controller', North American Power Symposium, NAPS, Cleveland, Ohio, October 1998*
21. *Uzunovic, E., Canizares, C.A., Reeve, J., 'EMTP Studies of UPFC Power Oscillation Damping', Proceedings of the North American Power Symposium (NAPS), San Luis Obispo, CA, October 1999, pp. 405-410*
22. *Huang, Z., Ni, Y., Shen, C.M., Wu, F.F., Chen, S., Zhang, B., 'Application of Unified Power Flow Controller in Interconnected Power Systems -- Modeling, Interface, Control Strategy and Case Study', IEEE Power Engineering Society Summer Meeting, 1999*
23. *Dynamic Tutorial and Functions, Power System Toolbox Version 2.0, Cherry Tree Scientific Software, Ontario, Canada*
24. *Hiyama, T, Hubbi, W., Ortmeyer, Th., 'Fuzzy Logic Control Scheme with Variable Gain for Static Var Compensator to Enhance Power System Stability', IEEE Transactions on Power Systems, Vol. 14, No. 1, February 1999, pp. 186-191*
25. *Hiyama, T, 'Fuzzy Logic Switching of Thyristor Controlled Braking Resistor Considering Coordination with SVC', IEEE Transactions on Power Delivery, Vol. 10, No. 4, October 1995, pp. 2020-2026*

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